RVLT Project Monthly Report for AAVP

August 2015

South Lighthouse, Fair Isle

Point Vicente Lighthouse, CA

Pierres Noires Lighthouse, France

UK

Oriana, UK

Canada

based on financial data from end of Aug 2015

RVLT Summary

Risks
- LaRC requested risk wording change for RVLT Risk-7.

Project Management
- Working on Thrust 3B (Vertical Lift) Roadmap
- Augmentation money is 100% committed, 95% obligated (Sept 13 number)
- Project Procurement is 99% committed; 93% obligated (Sept 21 number)
- Overall project is 94% committed; 89% obligated (Sept 15 number)
- Team meeting at GRC on Sept 16

International agreement(s)
- No changes in last month

Other:
- Date selected for celebration at HQ of 50th Anniversary of NASA/Army agreement. Sept. 23 was rescheduled due to papal visit to DC. Rescheduled for Nov. 6
- NDARC was distributed to NASA Langley Research Center, Aeroelasticity Branch; Department of Transportation, Volpe Center; and Georgia Institute of Technology
- Discussions continue with UTRC for development of a non-reimbursable SAA for vaneless diffuser research (follow-on to NRA)

RW Project Manager's Assessment

Program/Project: Revolutionary Vertical Lift Technologies

Status as of: 09/09/15

	JUL	AUG	SEP	OCT	
Cost	G	Y	Y	G	Concern about 1 large PRs obligating through NSSC for SBIR Phase 3
Schedule	G	G	G	G	
Technical	G	G	G	G	
Mgmt. Issues	G	G	G	G	

- **G** — Progress according to plan. Meeting management plans or commitments. No action required.
- **Y** — Area of concern. Deviating from plans or commitments, but approved contingency/ reserves exists to recover and successfully complete the program/project as approved. Needs attention. Problem can be resolved within the reporting organization.
- **R** — Significant problem. Deviating from plans or commitments, with insufficient approved contingency/reserves to recover and successfully complete the program/project as approved. Needs action. Help required beyond the reporting organization to address the problem.
- **B** — Change to original Baseline

WHAT'S GOING WELL

Recent Key Meetings and Activities

Month	Date	Event	Significance
Aug	3-4	Transformative Vertical Flight Workshop	Second annual workshop to discuss progress and way forward to enable electric propulsion vertical flight concepts.
Aug	9-12	44th Inter-Noise Congress & Exposition on Noise Control Engineering, San Francisco	Ran Cabell participated in the Technical Advisory Board meeting for the Institute of Noise Control Engineering and chaired a noise and vibration control session. Noah Schiller chaired sessions on noise control and active vibration control and presented an invited paper assessing the accuracy of several commonly used analytical sound transmission loss models. Significant interest and possible collaborations under discussion as a result.
Aug	13	Sikorsky briefing on acoustic metrics task order by Eric Jacobs.	Briefing on what Sikorsky views as important for helicopter noise and design for low noise. Participation by many NASA at multiple centers and also FAA over WebEx.
Aug	19-20	NRTC FY14 Year End Review and Airloads Workshop at Georgia Tech	Last Airloads Workshop sponsored under NRTC. Tom Norman presented planned updates to data sets available by end of September. Next year it is expected to continue Airloads Workshop under new contract.
Aug	25	CAS Big Idea Workshop @ LaRC	Development of possible new big questions to help guide CAS proposers
Aug	26	Meeting with Aaron Isaacson and Sean McIntyre of Penn State to discuss windage and loss of lube experiments	Collaboration between GRC and Penn State under non-reimbursable SAA contributes to Tech Challenge completion
Aug	26	Visit to University of Akron for discussion of an integrated sensor for lubricant oil condition.	Sensor was tested on new and used oil from Spiral Bevel Gear Fatigue Test. Sensor is very close to being ready to use in a test rig, but needs sensitivity to particles of 25microns. Will continue to monitor progress.
Aug	26-27	Blue Sky Workshop @ LaRC on Quiet VTOL	Ideas were exchanged on possible configurations for three future VTOL missions

LOOK AHEAD

Month	Dates	Event	Attendees
Sept	11	Jonathan Hartman, Sikorsky Aircraft visit to LaRC	Gorton, Cabell, Tran, Boyd, etc
Sept	14-16	Boeing IRAD review, St. Louis	Gorton
Sept	15-17	RVLT Team meeting @ GRC	RVLT team
Sep	22-25	AHS Ottawa Chapter Conference: "Sustainability 2015" - Montreal, Canada	D. Boyd
Sept	25	UTRC NRA final briefing for AFC	Schaeffler, Gorton, Theodore, Lunsford, Allan, Norman, Yamauchi
Sept	29	GTRI Noise Task Order Final Briefing	Boyd, others
Sept	29	P&W Test Readiness Review @ AATD	Suder
Oct	14	RVLT Annual Review Rehearsal	Gorton, others
Oct	21	ASEB presentation, Ivrvine, CA	Gorton, presenting
Oct	27-29	AHS Propulsion Specialists' Meeting, Williamsburg	Gorton, presenting
Nov	2-4	AAVP Project Annual Review	Gorton, Theodore
Nov	6	NASA/Army 50th Anniversary Event @ HQ	ARMD, AAVP, RVLT, Army, ARC, LaRC, GRC
Nov	10-11	VLRCOE review, Penn State	Gorton, Theodore, Boyd, Krantz, Roberts, Kreeger
Nov	12-13	VLRCOE review, UMD	Gorton, Theodore, Boyd, Buning, Norman, Washburn
Nov	18-19	VLRCOE review, GaTech	Gorton, Theodore, Boyd, Yamauchi, Lee-Rausch, Schaeffler, Kreeger

RVLT Project Risks

Risk #	CAT	TC/Res Theme	Risk Description	Trend	L	C	Approach	Comments (Aggregate Risks, Mitigation, Elevate?)
RVLT-Risk 1	CTS	TTR Capability Challenge	If Tiltrotor Test Rig hardware checkout uncovers issues, cost increases or schedule slips could occur	➔	3	2	A	Critical lift complete; preparations for drive train checkout and instrumentation continue
RVLT-Risk 6	CTS	TTR Capability Challenge	If NFAC has DoD priorities, schedule for TTR may change and require additional resources for preparation and impact technical content	➔	4	3	W	DoD is proposing possible testing in the NFAC that may impact the TTR functional checkout currently scheduled for May 2016. No updates to DoD schedule this month.
RVLT-Risk 7	CTS	Low Noise Rotor Design Capability	If the Structural Adjoint method is not developed due to either technical or budget difficulties, there is a possibility that the Tech Challenge will need to be de-scoped.	➔	3	5	W	Investigating minimum and full success criteria for Technical Challenge

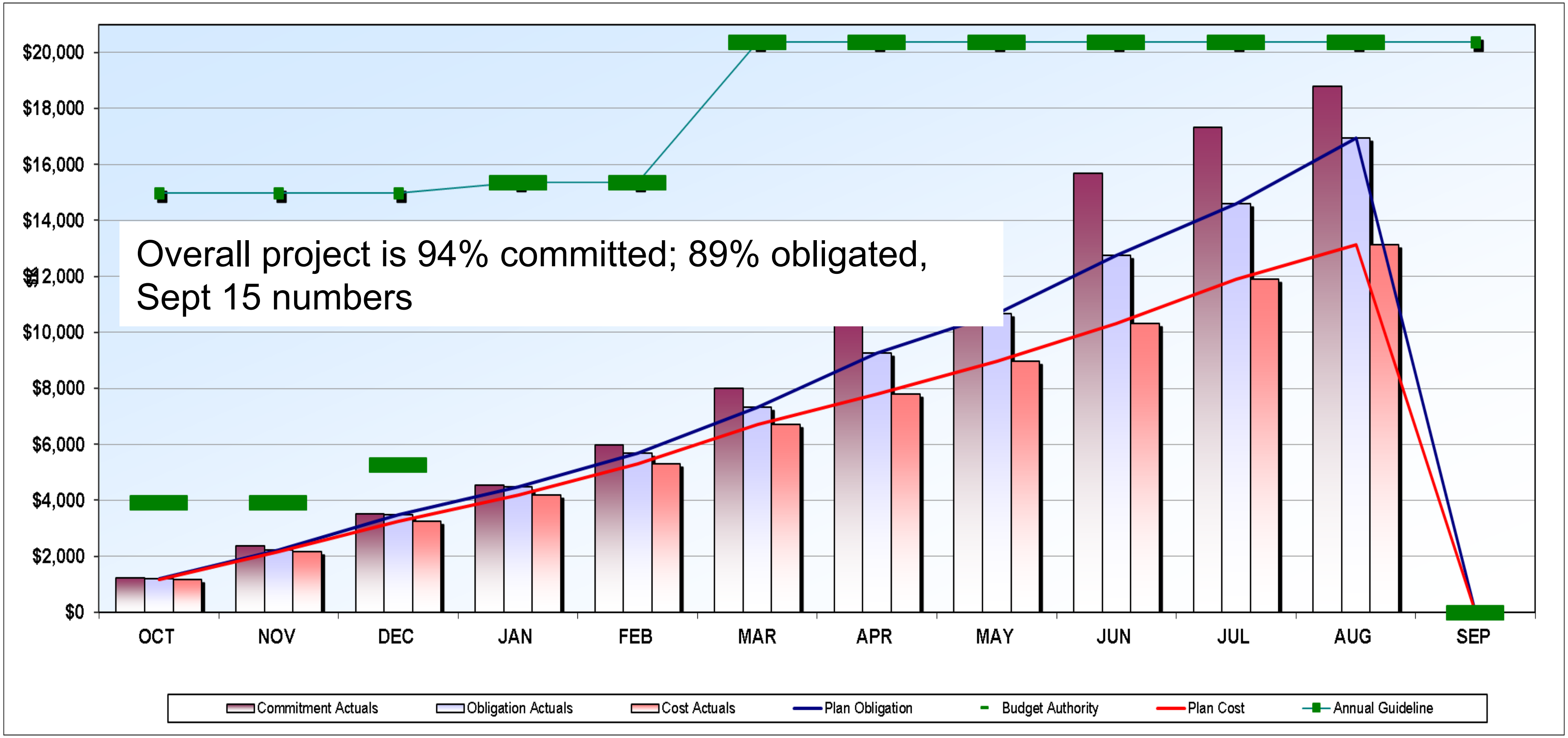
•Legend

•CAT of Risk	**L x C Trend** (Likelihood, Consequence)	**Approach**
•C=Cost	🡇 Decreasing (Improving)	M=Mitigate
•T=Technical	🡅 Increasing (Worsening)	W=Watch
•S=Schedule	➔ Unchanged	A=Accept
	☐ New since last period	R=Research

09/15/2015

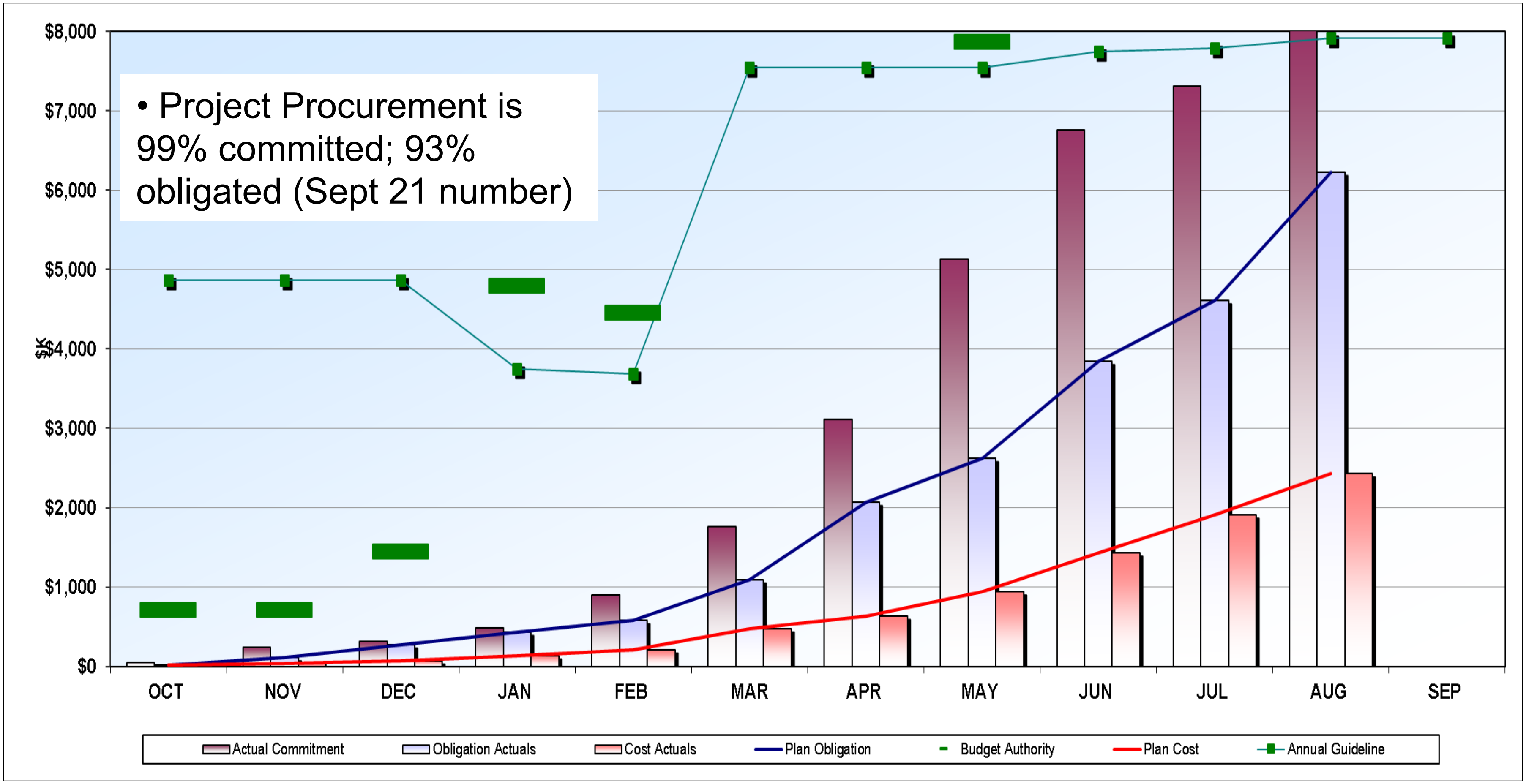
•Pre-decisional: Government Use Only

Revolutionary Vertical Lift Technology / RVLT Full Cost Summary



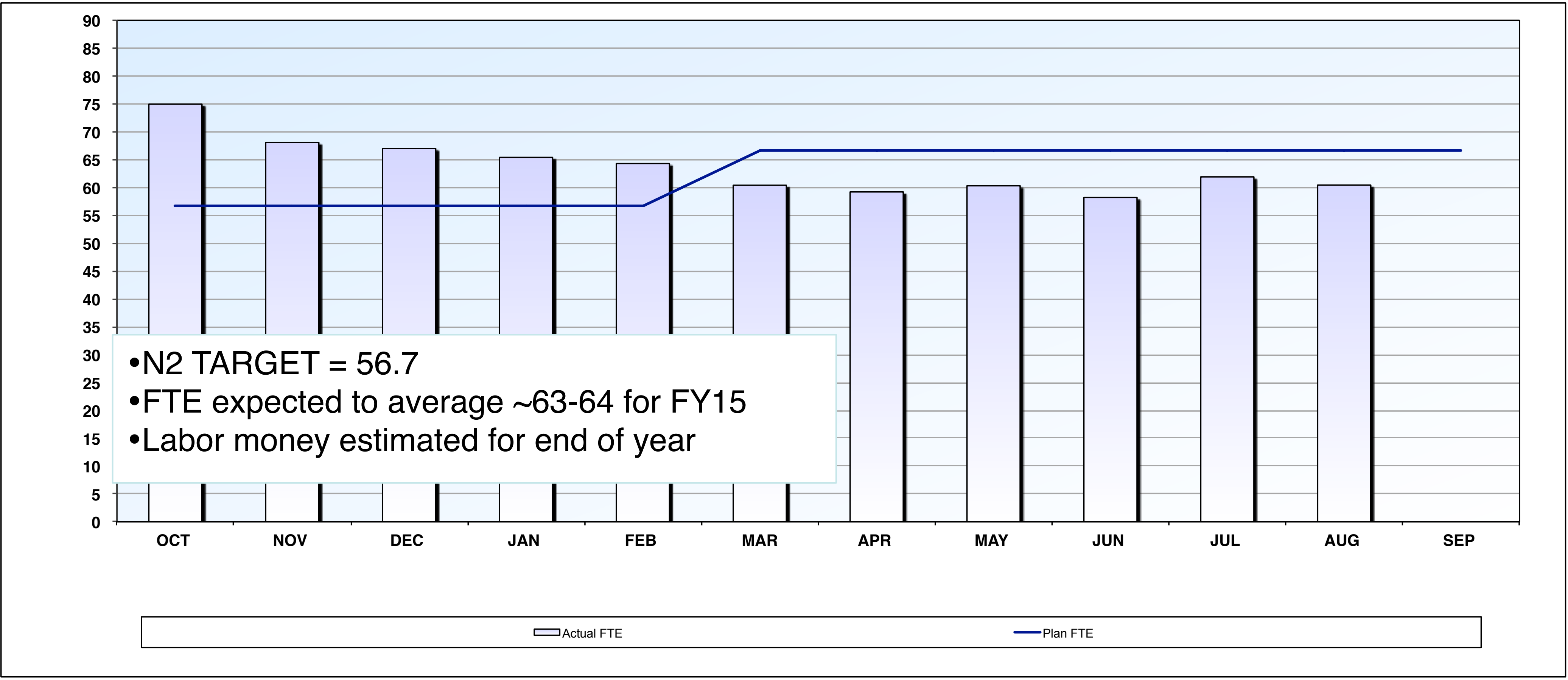
FY2015	Full Cost Summary													
COMMITMENT	CARRY IN	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	CARRY OUT
BW Actual	-	$1,221	$2,360	$3,513	$4,548	$5,987	$8,002	$10,311	$13,182	$15,674	$17,316	$18,803	$0	$2,325
OBLIGATION	CARRY IN	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	CARRY OUT
Plan	-	$1,188	$2,224	$3,472	$4,490	$5,671	$7,330	$9,262	$10,673	$12,756	$14,608	$16,954	$0	$5,033
BW Actual	-	$1,188	$2,224	$3,472	$4,490	$5,671	$7,330	$9,262	$10,673	$12,756	$14,608	$16,954	$0	$5,033
Variance (Actual-Plan)		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Percentage ((Actual-Plan)/Plan)		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	#DIV/0!	
COST	CARRY IN	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	CARRY OUT
Plan	-	$1,170	$2,155	$3,257	$4,183	$5,294	$6,702	$7,805	$8,976	$10,324	$11,890	$13,130	$0	$7,767
BW Actual	-	$1,170	$2,155	$3,257	$4,183	$5,294	$6,702	$7,805	$8,976	$10,324	$11,890	$13,130	$0	$7,767
Variance (Actual-Plan)		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Percentage ((Actual-Plan)/Plan)		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	#DIV/0!	
Annual Guideline		$14,966	$14,966	$14,966	$15,370	$15,370	$20,370	$20,370	$20,370	$20,370	$20,370	$20,370	$20,370	$0
Budget Authority		$3,926	$3,926	$5,285	$15,370	$15,370	$20,370	$20,370	$20,370	$20,370	$20,370	$20,370	$0	

Revolutionary Vertical Lift Technology / RVLT Procurement



FY2015	Procurement													
COMMITMENT	CARRY IN	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	CARRY OUT
BW Actual	-	$53	$244	$313	$487	$899	$1,765	$3,114	$5,129	$6,761	$7,317	$8,075	$0	$605
OBLIGATION	CARRY IN	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	CARRY OUT
Plan	-	$20	$108	$272	$429	$583	$1,093	$2,065	$2,620	$3,843	$4,609	$6,226		$3,313
BW Actual	-	$20	$108	$272	$429	$583	$1,093	$2,065	$2,620	$3,843	$4,609	$6,226		$3,313
Variance (Actual-Plan)		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	
Percentage ((Actual-Plan)/Plan)		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	#DIV/0!	
COST	CARRY IN	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	CARRY OUT
Plan	-	$15	$42	$68	$135	$211	$473	$632	$937	$1,426	$1,906	$2,433		$6,016
BW Actual		$15	$42	$68	$135	$211	$473	$632	$937	$1,426	$1,906	$2,433		$6,016
Variance (Actual-Plan)		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	
Percentage ((Actual-Plan)/Plan)		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	#DIV/0!	
Annual Guideline		$4,866	$4,866	$4,866	$3,751	$3,681	$7,545	$7,545	$7,545	$7,745	$7,794	$7,922	$7,922	
Budget Authority	-	$715	$715	$1,454	$4,804	$4,464	$8,156	$8,156	$7,876	$8,013	$8,001	$8,127		

Revolutionary Vertical Lift Technology / RVLT FTE



FY2015 FTE		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Cumm Ave
Plan		56.7	56.7	56.7	56.7	56.7	66.6	66.6	66.6	66.6	66.6	66.6	66.6	
Actual		75.0	68.1	67.0	65.4	64.3	60.4	59.2	60.3	58.2	61.9	60.4		63.7
Variance (Actual-Plan)		18.3	11.4	10.3	8.7	7.6	(6.2)	(7.4)	(6.3)	(8.4)	(4.7)	(6.2)	(66.6)	
Percentage ((Actual-Plan)/Plan)		32.2%	20.1%	18.2%	15.3%	13.4%	-9.3%	-11.1%	-9.5%	-12.6%	-7.1%	-9.3%	-100.0%	

High Fidelity CFD

- Continued to do fine tuning of the FUN3D rotorcraft capability and the integration with HELIOS/CREATE (Bob Biedron)
  - Generalized the shaft angle to allow input of an arbitrary angle via specification of 3 Euler angles (previously allowed only fore/aft tilt).
  - Added two FUN3D-HELIOS tests to the FUN3D regression test suite so that any breakage of the current HELIOS capability will be known at as soon as possible.
  - Added the rotor performance output from FUN3D back in when coupled with HELIOS
  - Will continue testing the integration
- Installed July 27, 2015 HELIOS interface updates from Rohit Jain (AFDD) into OVERFLOW (Pieter Buning)
- Continued work on vortex visualization techniques applicable to both CFD and experimental data sets (David Kao)
- Continued work on implementation of actuator disk model in OVERFLOW (Jasim Ahmad)
- Determined that CFD solution was very sensitive to small changes in compiler when test condition is near stall. Re-evaluating calculated effect of walls in NFAC on small rotor due to this discovery. Initial indications are that wall effects are much smaller than first calculated – which would be the more expected result (Neal Chaderjian)
- Preparing near-body Adaptive Mesh Refinement for application to dynamic stall and blade vortex interaction calculations (Neal Chaderjian)

High Fidelity CFD and Acoustic Coupling

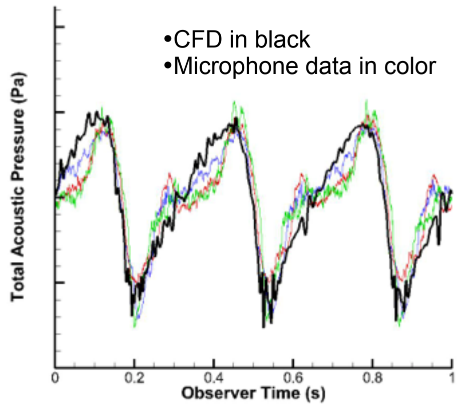
The Tiltrotor Aeroacoustic Model (TRAM) configuration is being used as a first test case for validating FUN3D and WOPWOP3/ANOPP2 aeroacoustic analysis. The TRAM aeroacoustic data have been retrieved from archive. The team identified an initial simple test case for a hover test condition where thickness noise should be the dominant component. Initially, the rotor is treated as a rigid structure with no coupling to CSD codes. The computed noise from an observer in the plane of the rotor is compared with fixed microphone data (Mic14 and Mic 15) from the hover case.

FUN3D/WOPWOP3 results are compared with OVERFLOW2/ WOPWOP3 and FUN3D/Helios/WOPWOP3 computations. A comparison of computed and wind-tunnel acoustic pressure data at the fixed microphone locations is shown. The OVERFLOW computation is time-accurate with a delayed detached-eddy turbulence model. The FUN3D computation is steady-state non-inertial computation with a RANS (SAR) turbulence model.

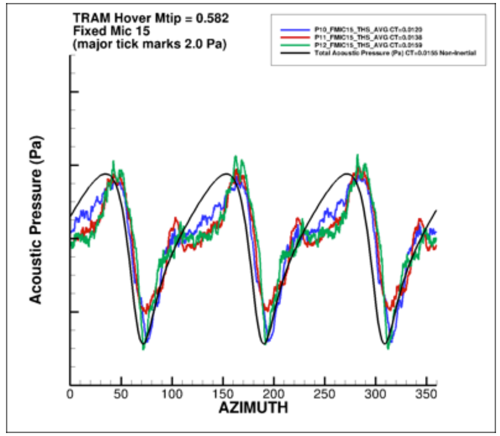
Comparisons between FUN3D/WOWOP3 and FUN3D/Helios/ WOPWOP3 results have been made at the higher hover tip Mach number case (0.62). Since there is no corresponding wind tunnel data, a comparison of acoustic pressure was made at 10R edgewise in the plane of the rotor. Carpet plots of total OASPL in a vertical plane below the blade show the overall sound pressure level (OASPL) calculated by each method.

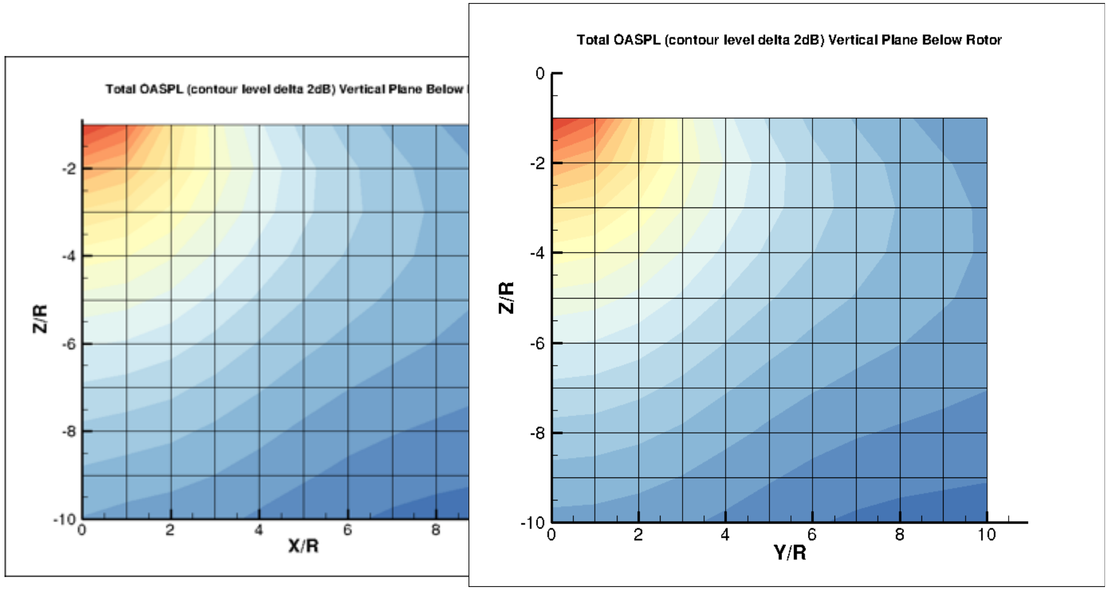
(Beth Lee-Rausch (FUN3D), Doug Boyd (OVERFLOW, acoustics), Gloria Yamauchi (TRAM, acoustics))

FUN3D



OVERFLOW

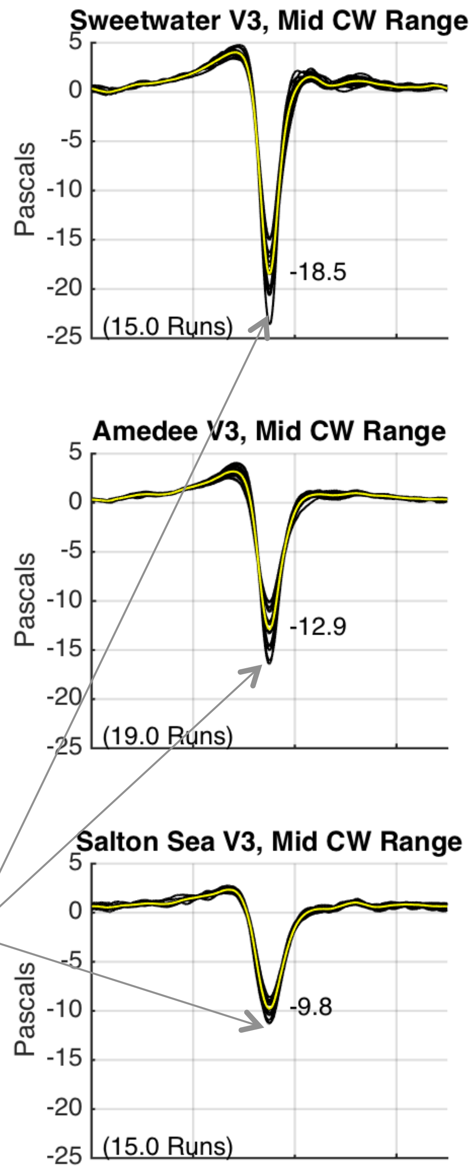




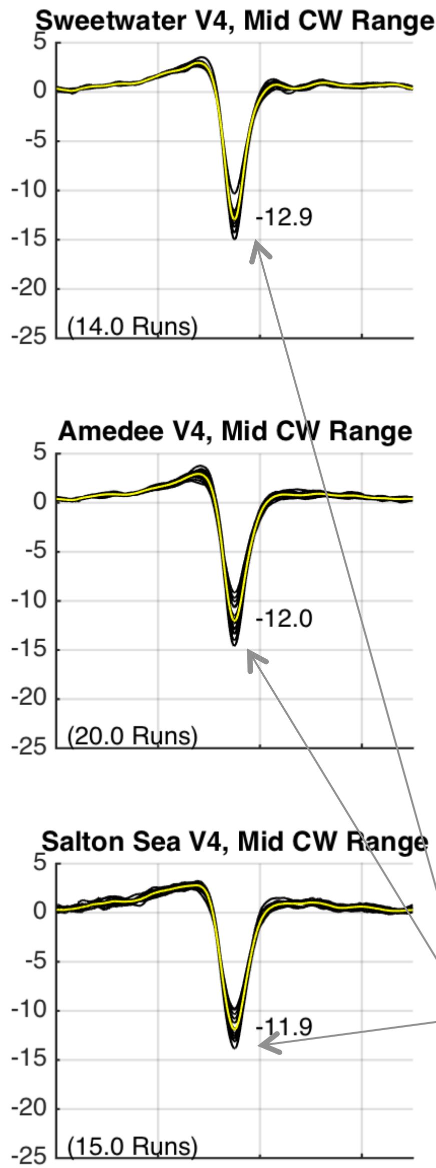
Comparison of FUN3D/Helios/WOPWOP3 (left) and FUN3D/ WOPWOP3 (right) predicted OASPL in a vertical plane below the blade at z=0 – red high, blue low.

Preliminary Data from Acoustic Flight tests

Shows effect of altitude using "standard" non-dimensional parameters; data at sea level not the same at altitude! (Confirms the FRAME theory and predictions.)



Pressure peak changes level at 3 altitudes.



Data show that using a new non-dimensional parameter to collapse acoustic data gives results that can be used from sea level to altitude for acoustic prediction. This is a new and exciting result for acoustic predictions and noise footprint calculations!

Pressure peak all ~ same level using new non-dimensional parameter at 3 altitudes.

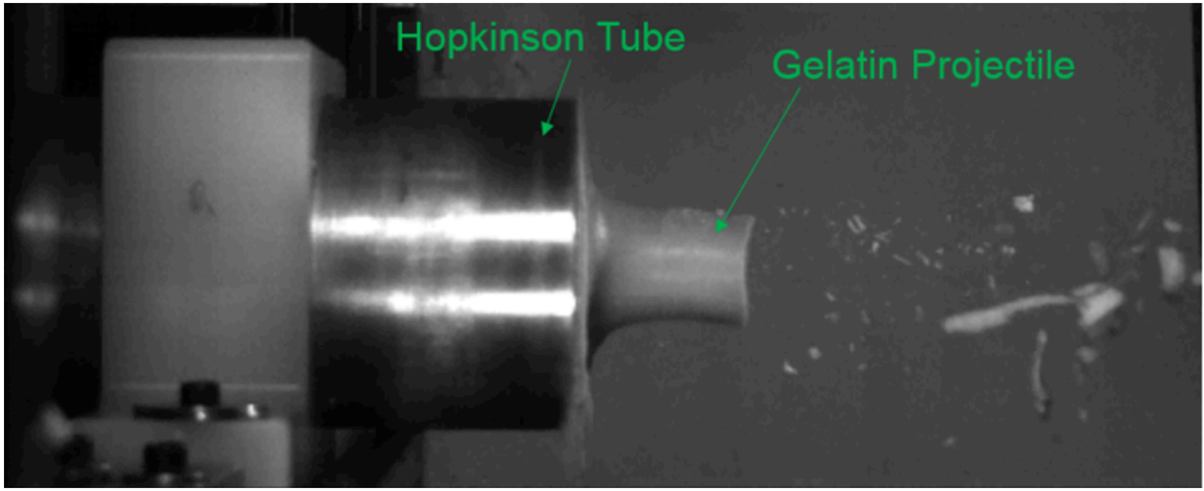
Safety and Environment Highlights

- Work continues on investigation of lightweight, load-carrying structure that can also be an acoustic absorber. Sandwich panels have been constructed and will be tested in September. Pre-test predictions of panel behavior have been calculated. Additionally, vehicle-level models where the walls of the cabin are made or tuned chamber-core panels are being developed to assess the noise reduction performance of the new structure compared to conventional foam treatment. (Noah Schiller, Al Allen)
- Icing branch personnel participated in a mid-year review and site visit of Vertical Lift Research Center of Excellence (VLRCOE) and NASA Research Announcement (NRA) activities underway at the Pennsylvania State University on August 17-18, 2014 in State College, PA. The feasibility of conducting Supercooled Large Droplet (SLD) testing in the Adverse Environment Rotor Test Stand (AERTS) facility was discussed. Heat transfer experiments and computational modelling efforts for rotor blade icing were also reviewed. New heat transfer measurements have been made for realistic roughness on both airfoils and cylinders. This work in particular shows promise for future generations of rotorcraft icing tools, and involves both the PSU Department of Aerospace Engineering and the PSU Advanced Research Laboratory (ARL). Discussions were also held on an upcoming Icing Branch collaboration to use the AERTS to visualize droplet breakup. (Eric Kreeger)

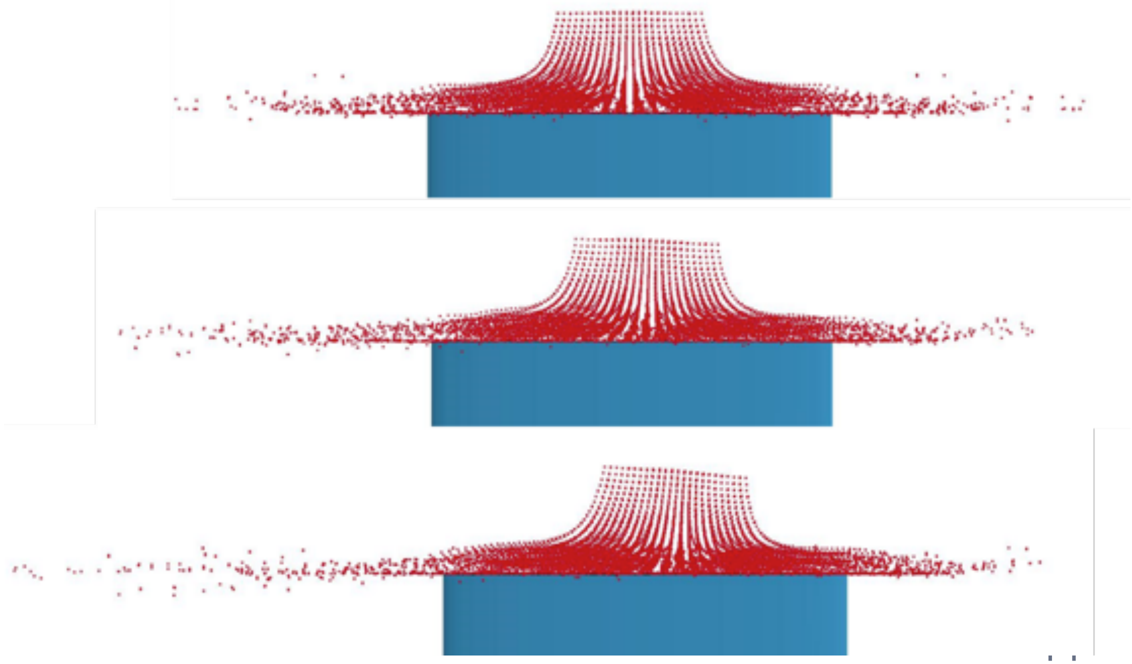
Safety and Environment Highlights

- During this period impact tests were conducted at GRC on the Hopkinson tube apparatus using gelatin cylinders as projectiles, and simulations of impact tests at different angles of incidence were conducted at LaRC. The figure shows an image from high speed video of the gelatin projectile impacting the tube. The impact velocities ranged from 488 ft/sec to 1337 ft/sec.

- The original bird strike models were modified such that the impact mass (bird) was rotated about the lateral x-axis. The rotations used in the simulations were 2.5 and 5.0 degrees, respectively. The only changes to the simulations were the rotation of impact mass. The figure shows the deformed shapes at an elapsed time of 0.005 seconds for the three simulations. Clearly evident is the increased displacement of impact mass in the y-direction, increasing as the rotation angle increases.



Gelatin projectile impacting Hopkinson Tube



Impact Mass Deformed Shapes, t = 0.005 sec.

(GRC/LMD/Mike Pereira; LaRC/D322/Martin Annett)

NASA-DLR Implementing Arrangement under Framework Agreement

- Markus Raffel from DLR visited Ames during the first two weeks of September, where discussions regarding the work done under the new NASA-DLR agreement began in earnest. A meeting with Gloria Yamauchi, Alan Wadcock, Mani Ramasamy (US Army) and Neal Smith along with PI's Heineck and Raffel covered many areas under the agreement. First, the schedule: current plans are to piggy-back efforts on the reconstruction of the Rotor Test Rig (RTR) using an existing blade set. The first effort will be to integrate and test the Thermal Imaging system in the Hover Chamber after the RTR is installed and tested. Soonest availability for all participants will be February, 2016. There will be a large window of testing opportunity after that. The eventual goal is to install the RTR and Thermal imaging system in the 7 x 10 Wind Tunnel in Summer of 2016 for obtaining thermal data for discreet azimuthal locations of the whole rotor disk in forward flight.

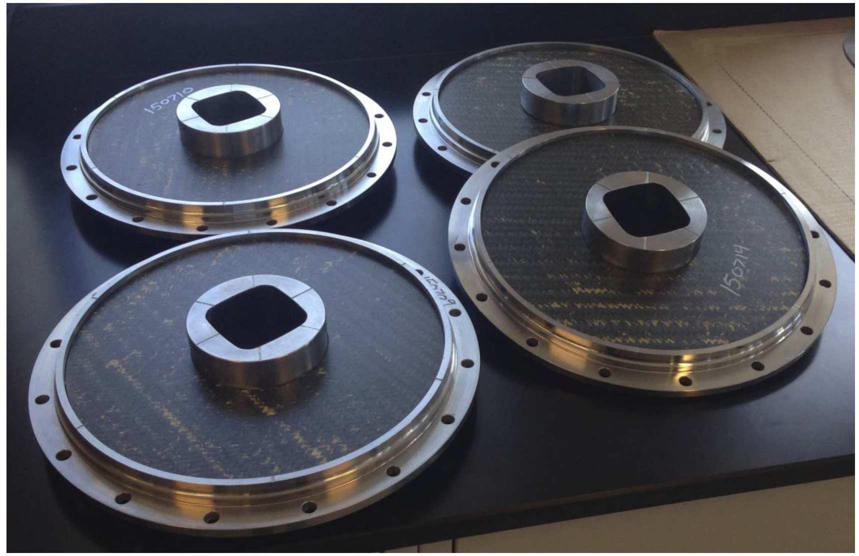
- Raffel then presented work done at DLR Goettingen that was recently published in several articles in Experiments in Fluids. He explained the Differential Infrared Thermography technique, which uses two registered thermal images of the blade at different collective pitches. The results show a more clearly defined location of transition, which can be mapped back to a surface grid of a given blade and directly compared to a CFD result. We at Ames will need to come up to speed with our processing codes and working with DLR will accelerate our capability.

(JT Heineck, Gloria Yamauchi, Markus Raffel)

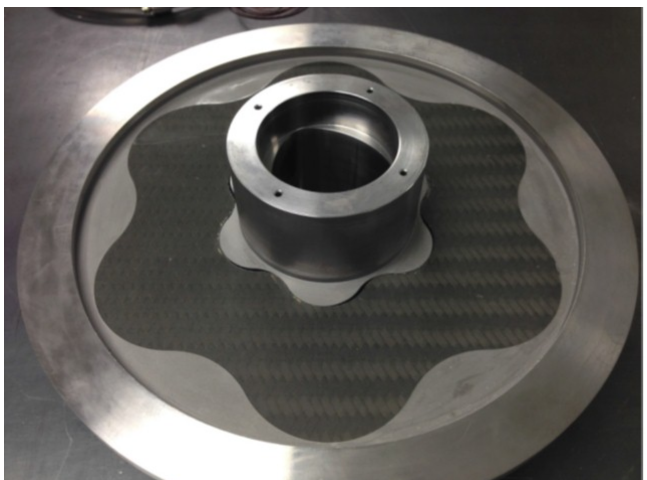
Highlights

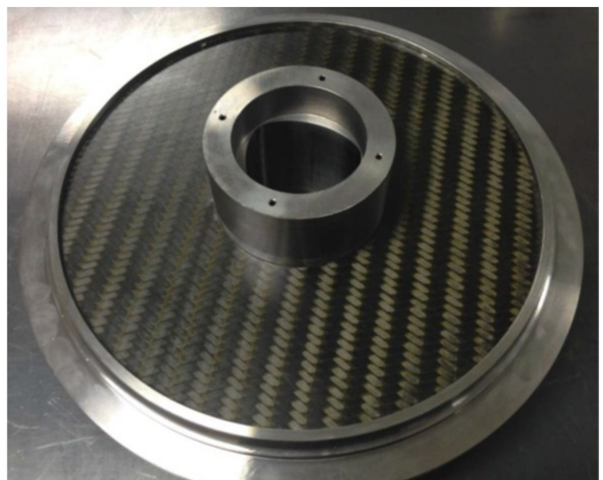
- **Multispeed Drive System Modeling:** This month a contract was put into place with Penn State and University of Tennessee. The research task is to extend a previously developed modeling tool for multispeed propulsion systems for rotorcraft. The existing Simulink modeling tool did not include any “module” for electric motors or generators. The GRC multispeed test stand uses an electric motor to drive a generator through a 2-speed driveline. The Penn State and U. of Tennessee team is tasked with modeling the GRC test setup. This model will allow to better understand GRC testing and to help determine if clutch behavior and driveline dynamics such as torque spikes will be similar in an aircraft as experienced in the test stand. The work will support the completion of the Two-Speed Drive Systems Tech Challenge. (Krantz, Scheidler)
- **Two-Speed Drive Hardware:** Design activities during August focused on Configuration 3: Wet-Clutch. Time was spent on assembly drawings & procedures, manufacturing and assembly support, and new design. The wet clutch configuration is a design intended to reduce the torque spike during the transmission shift. This work supports the Two-Speed Drive Systems Tech Challenge. (Stevens, Krantz)
- **Hybrid Composite Gear:** The hybrid gear research team completed baseline bull gear testing the week of August 10th. Vibration and orbit data from these tests will be used as a baseline comparison for upcoming bull gear tests. The hybrid bull gear project required a redesign of the gear assembly from its original design, to allow the same gear and shafting to be used while testing multiple different hybrid web configurations. (Roberts, LaBerge, Thorp)

Hybrid Gear Status



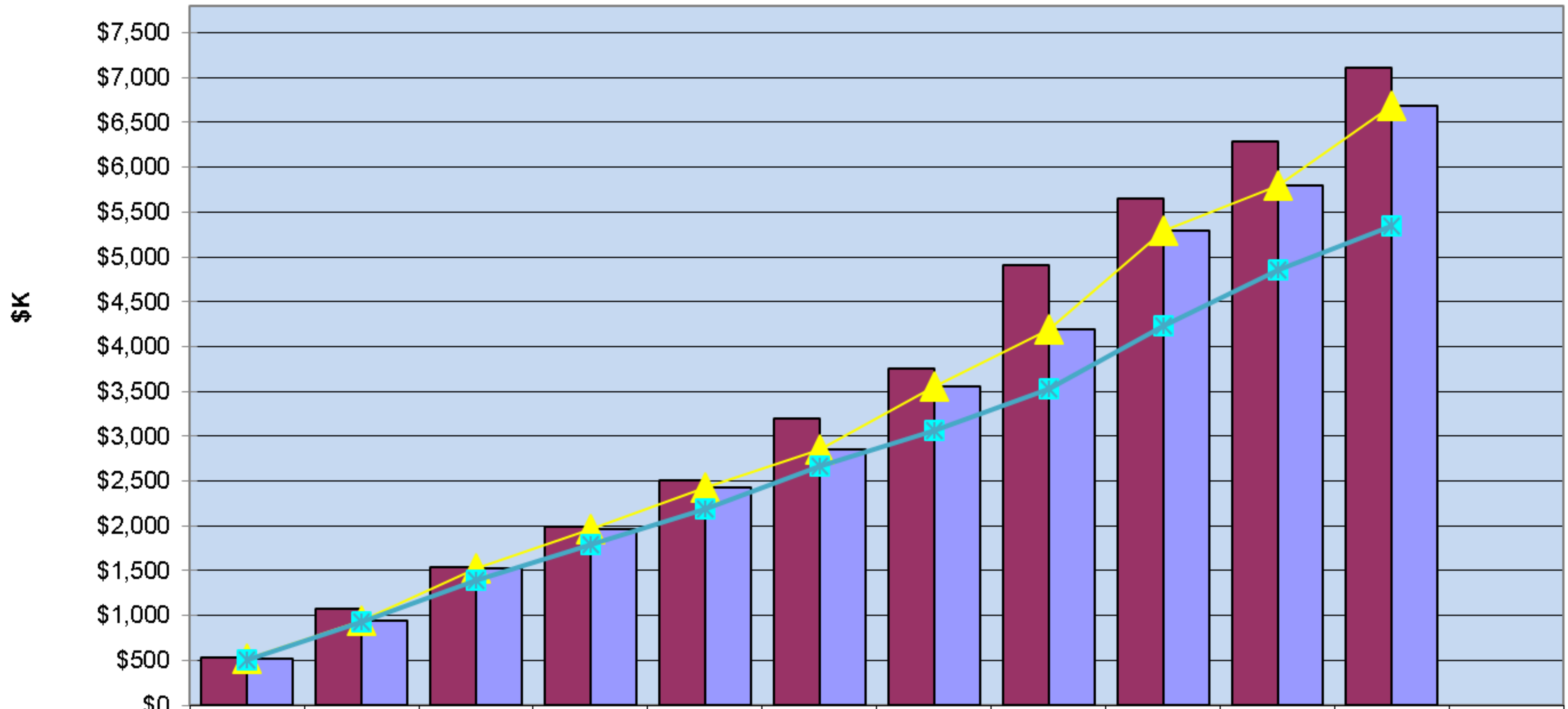
- Quasi-static torsion testing on hybrid gear structures has begun with A&P under SBIR. The first four tests are being done at room temperature. Four additional tests will be performed at elevated temperature.
- All of the test articles have a lobed interlock feature between the inner composite layer and the steel hub and rim adapter sections. The lobed interlock feature is identical to that used for the hybrid gears that will be run in the high speed helical gear test rig (SW-8 test cell). This interlock feature is shown below for the first hybrid gear that was fabricated. The picture on the left below shows the internal interlock feature between a lobe-shaped composite panel and the steel lobes of the hub and rim adapter. The picture on the right shows an assembly including the top composite annular ring which is secondarily bonded to the lobe-shaped composite internal panel and to the steel lobes of the hub and rim adapter. A similar annular ring is bonded on the bottom so that the internal lobe-shaped composite panel is captured between the top and bottom composite panels to prevent axial displacement.





Backup

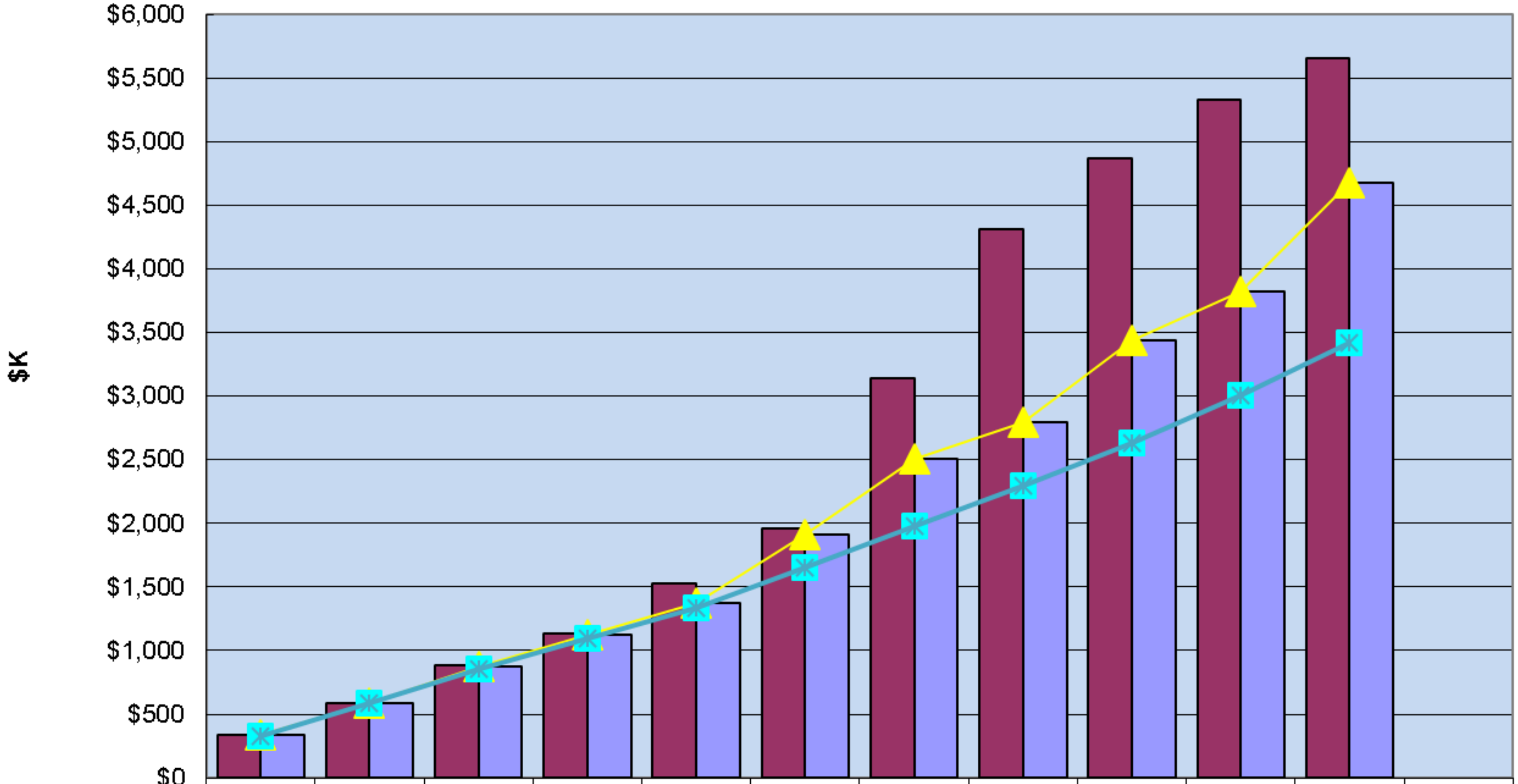
ARC FY15 RVLT Full Cost Plan vs Actual
As of August 31, 2015



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
Cum Com Act	$538	$1,070	$1,546	$1,992	$2,513	$3,196	$3,755	$4,907	$5,655	$6,282	$7,111	
Cum Obl Plan	$512	$946	$1,520	$1,959	$2,430	$2,846	$3,549	$4,190	$5,299	$5,800	$6,689	
Cum Obl Act	$512	$946	$1,520	$1,959	$2,430	$2,846	$3,549	$4,190	$5,299	$5,800	$6,689	
Cum Cost Plan	$501	$936	$1,391	$1,785	$2,193	$2,664	$3,059	$3,531	$4,229	$4,852	$5,351	
Cum Cost Act	$501	$936	$1,391	$1,785	$2,193	$2,664	$3,059	$3,531	$4,229	$4,852	$5,351	

LaRC FY15 RVLT Full Cost Plan vs Actual

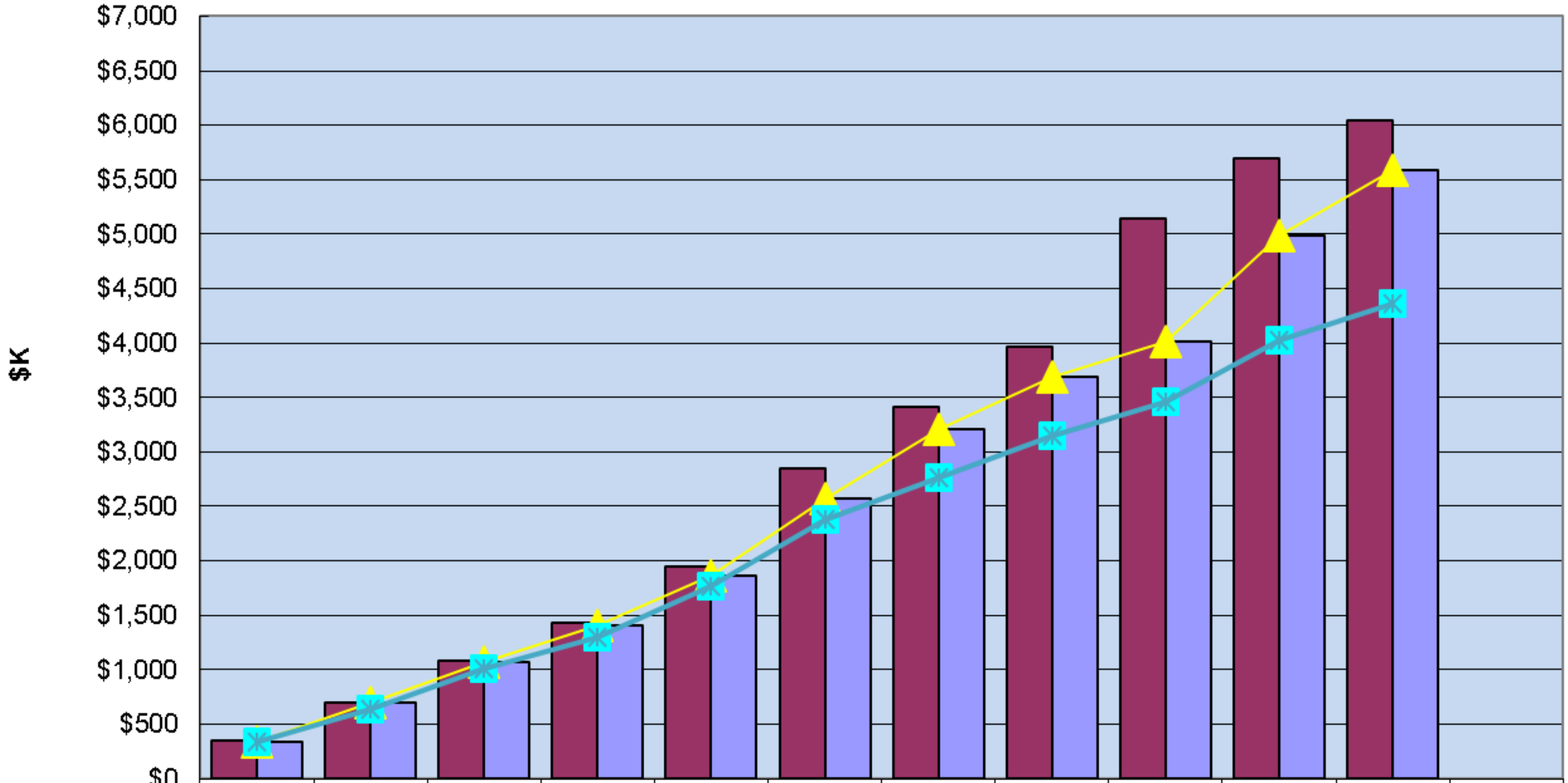
As of August 31, 2015



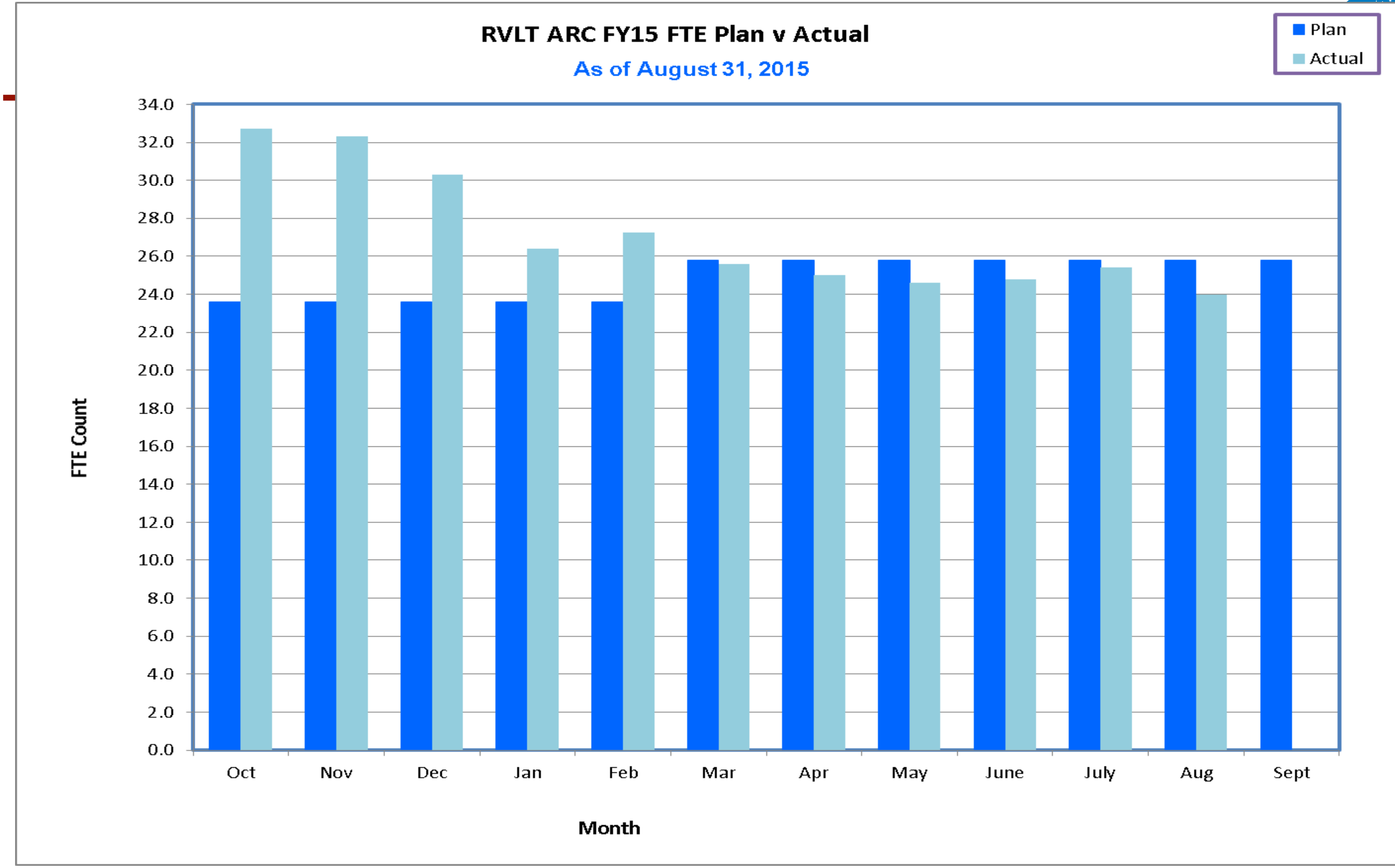
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
Cum Com Act	$337	$589	$881	$1,131	$1,526	$1,956	$3,141	$4,310	$4,872	$5,333	$5,652	
Cum Obl Plan	$335	$585	$877	$1,122	$1,376	$1,915	$2,508	$2,798	$3,442	$3,819	$4,680	
Cum Obl Act	$335	$585	$877	$1,122	$1,376	$1,915	$2,508	$2,798	$3,442	$3,819	$4,680	
Cum Cost Plan	$331	$584	$851	$1,097	$1,338	$1,653	$1,975	$2,294	$2,630	$3,008	$3,418	
Cum Cost Act	$331	$584	$851	$1,097	$1,338	$1,653	$1,975	$2,294	$2,630	$3,008	$3,418	

GRC FY15 RVLT Full Cost Plan vs Actual

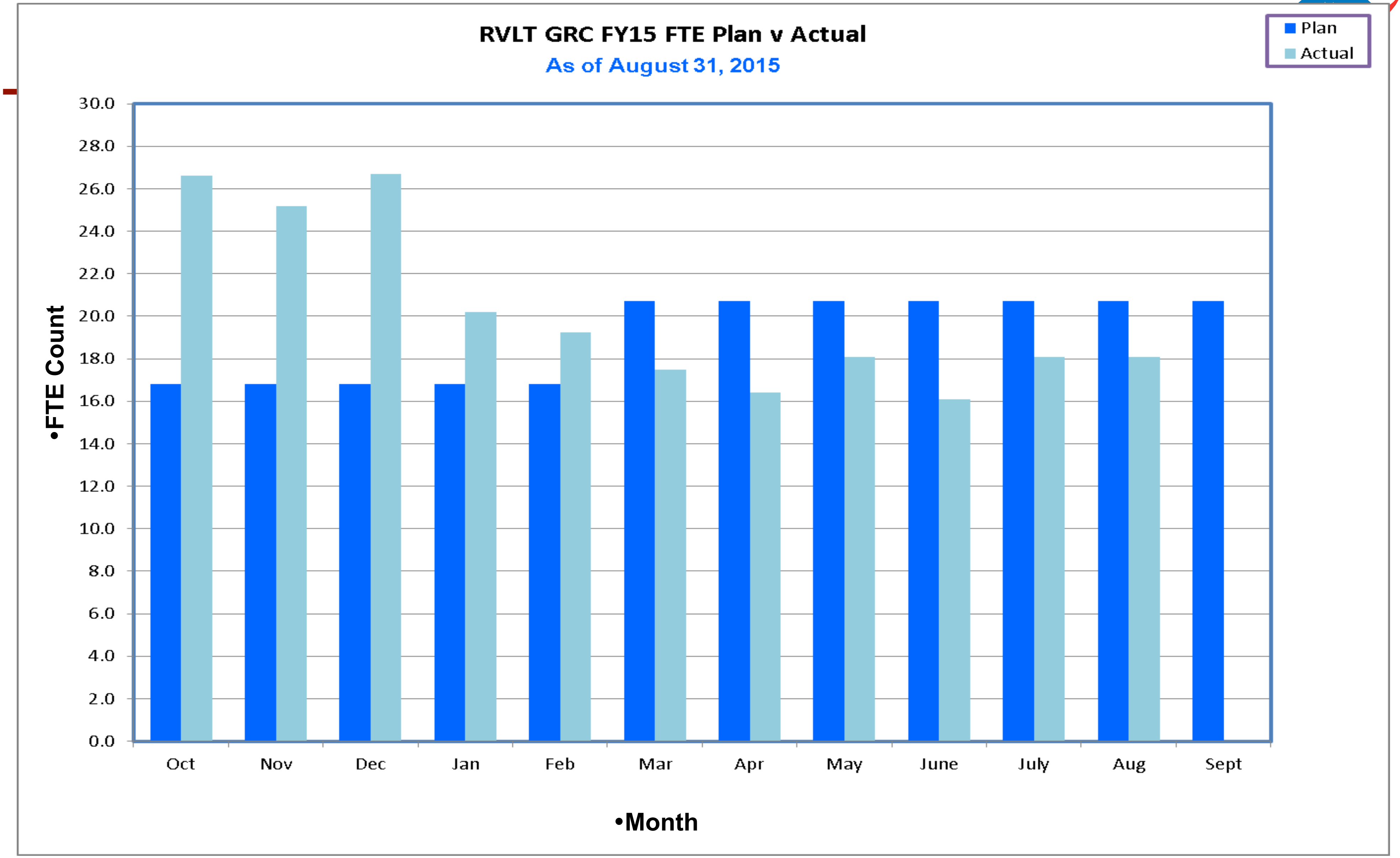
As of August 31, 2015



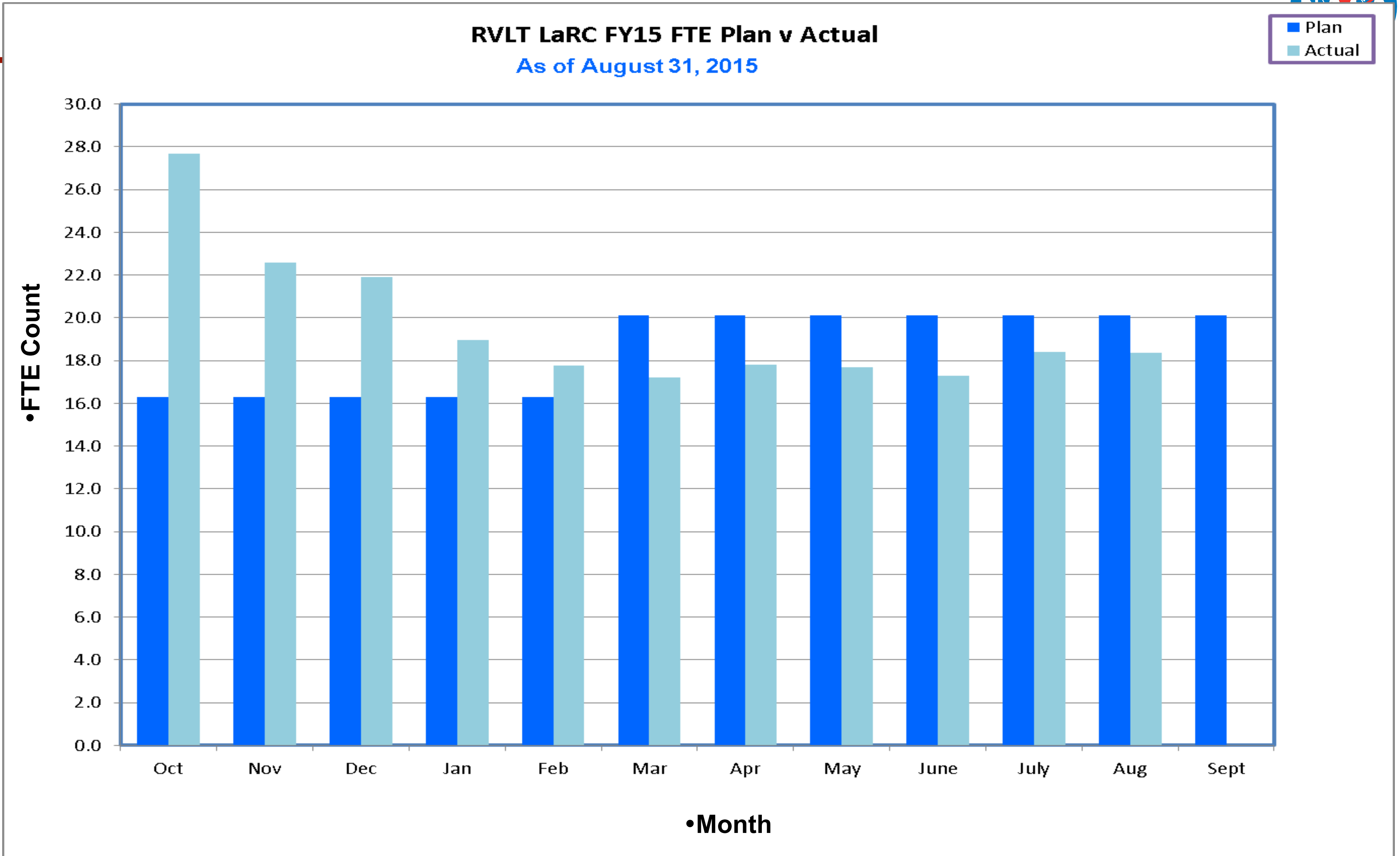
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
Cum Com Act	$344	$701	$1,086	$1,426	$1,949	$2,850	$3,414	$3,963	$5,146	$5,700	$6,042	
Cum Obl Plan	$341	$692	$1,075	$1,409	$1,864	$2,569	$3,204	$3,684	$4,016	$4,989	$5,586	
Cum Obl Act	$341	$692	$1,075	$1,409	$1,864	$2,569	$3,204	$3,684	$4,016	$4,989	$5,586	
Cum Cost Plan	$338	$633	$1,015	$1,302	$1,764	$2,385	$2,770	$3,151	$3,466	$4,029	$4,362	
Cum Cost Act	$338	$633	$1,015	$1,302	$1,764	$2,385	$2,770	$3,151	$3,466	$4,029	$4,362	



25.8					As of August 31, 2015							
ARC FTE	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
Plan	23.6	23.6	23.6	23.6	23.6	25.8	25.8	25.8	25.8	25.8	25.8	25.8
Actual	32.7	32.3	30.3	26.4	27.3	25.6	25.0	24.6	24.8	25.4	24.0	
Avg Act FTE	**32.7**	**32.5**	**31.8**	**30.4**	**29.8**	**29.1**	**28.5**	**28.0**	**27.7**	**27.7**	**27.4**	



20.7				As of August 31, 2015								
GRC FTE	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
Plan	16.8	16.8	16.8	16.8	16.8	20.7	20.7	20.7	20.7	20.7	20.7	20.7
Actual	26.6	25.2	26.7	20.2	19.3	17.5	16.4	18.1	16.1	18.1	18.1	
Avg Act FTE	**26.6**	**25.9**	**26.3**	**24.7**	**23.7**	**22.7**	**21.8**	**21.3**	**20.7**	**20.4**	**20.3**	



20.1				As of August 31, 2015								
LaRC FTE	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
Plan	16.3	16.3	16.3	16.3	16.3	20.1	20.1	20.1	20.1	20.1	20.1	20.1
Actual	27.7	22.6	21.9	19.0	17.8	17.2	17.8	17.7	17.3	18.4	18.4	
Avg Act FTE	**27.7**	**25.2**	**24.1**	**22.8**	**21.8**	**21.0**	**20.6**	**20.2**	**19.9**	**19.7**	**19.6**	